

WHAT IS CLAIMED IS:

1. An acceleration sensor comprising:

a piezoelectric element which is formed by stacking an even number of piezoelectric layers greater than or equal to four layers;

support members for supporting both ends of the piezoelectric element in the longitudinal direction; and

electrodes which are provided in between the layers and on the front and back faces of the piezoelectric element,

wherein the interlayer electrodes include an electrode which is segmented into portions in the longitudinal direction near inflection points between an expansion stress and a contraction stress applied to the piezoelectric element in response to the application of an acceleration and lead electrodes led to the ends of the piezoelectric element in the longitudinal direction,

the two types of interlayer electrodes are alternately stacked with the piezoelectric layers therebetween,

the interlayer electrode in the middle of the piezoelectric element in the thickness direction is the segmented electrode,

the electrodes on the front and back faces of the piezoelectric element are led to the ends of the piezoelectric element in the longitudinal direction in order to extract generated charge, and

the piezoelectric layers are polarized in the thickness direction so that, when the acceleration is applied, charge having the same polarity is extracted from the lead electrodes led to the ends in the longitudinal direction in the piezoelectric layers on both sides of the lead electrodes and so that the center portion and both end portions of each piezoelectric layer are polarized in opposite directions.

2. An acceleration sensor according to Claim 1, wherein the piezoelectric element is formed by stacking four piezoelectric layers, and

the piezoelectric layers are polarized in the thickness direction so that the piezoelectric layers on both sides of all the interlayer electrodes are polarized in opposite directions.

3. An acceleration sensor comprising:

a piezoelectric element which is formed by stacking an odd number of piezoelectric layers greater than or equal to five layers;

support members for supporting both ends of the piezoelectric element in the longitudinal direction; and

electrodes which are formed in between the layers and on the front and back faces of the piezoelectric element,

wherein the interlayer electrodes include electrodes which are segmented into portions in the longitudinal direction near inflection points between an expansion stress and a contraction stress applied to the piezoelectric element in response to the application of an acceleration and lead electrodes led to the ends of the piezoelectric element in the longitudinal direction,

the interlayer electrodes which are arranged on both sides of the piezoelectric layer in the middle of the piezoelectric element in the thickness direction are the segmented electrodes,

the two types of interlayer electrodes are alternately stacked with the piezoelectric layers therebetween, excluding the piezoelectric layer in the middle in the thickness direction,

the electrodes on the front and back faces of the piezoelectric element are led to the ends of the piezoelectric element in the longitudinal direction in order to extract generated charge, and

among the piezoelectric layers, the piezoelectric layer in the middle in the thickness direction is not polarized, and the other piezoelectric layers are polarized in the thickness direction so that, when the acceleration is applied, charge having the same polarity is extracted from the lead electrodes led to the ends in the longitudinal direction in the piezoelectric layers on both sides of the lead electrodes and so that the center portion and both end portions of each piezoelectric layer are polarized in opposite directions.

4. An acceleration sensor according to Claim 3, wherein the piezoelectric element is formed by stacking five piezoelectric layers, and

the piezoelectric layers excluding the piezoelectric layer in the middle in the thickness direction are polarized in the thickness direction so that the piezoelectric layers on both sides of the interlayer electrodes are polarized in opposite directions.

5. A manufacturing method for manufacturing an acceleration sensor, comprising the steps of:

preparing $4n$ planar green sheets made of piezoelectric ceramic, where n is an integer greater than or equal to 1;

applying a conductive paste on a surface of at least one of the green sheets at positions corresponding to a center portion and both end portions of individual piezoelectric elements in the longitudinal direction, whereby segmented electrodes are formed for a plurality of piezoelectric elements;

applying a conductive paste on surfaces of at least two of the other green sheets so

that the conductive paste is led to positions corresponding to ends of each piezoelectric element in the longitudinal direction, whereby lead electrodes are formed for the plurality of piezoelectric elements;

stacking the green sheets so that the segmented electrode and the lead electrodes are alternately arranged and so that the electrode in the middle in the thickness direction is the segmented electrode;

firing the green sheets to produce a piezoelectric ceramic fired compact which includes a plurality of piezoelectric layers and simultaneously baking the conductive paste;

forming polarization electrodes on the front and back faces of the piezoelectric ceramic fired compact, the polarization electrodes being segmented into portions according to the positions corresponding to the center portion and both end portions of each piezoelectric element;

applying a DC electric field to the polarization electrodes and in between the segmented electrode and the lead electrodes to polarize the piezoelectric ceramic fired compact in the thickness direction so that, when an acceleration is applied, charge having the same polarity is extracted from the lead electrodes in the piezoelectric layers on both sides of the lead electrodes and so that the center portion and both end portions of each piezoelectric layer are polarized in opposite directions;

interconnecting the portions of the polarization electrodes or forming continuous electrodes after removing the polarization electrodes, whereby lead electrodes leading to the ends of the piezoelectric element in the longitudinal direction are formed on the front and back faces of the piezoelectric element,

cutting the piezoelectric ceramic fired compact into individual piezoelectric elements; and

forming external electrodes on both end faces of the cut piezoelectric element and connecting the external electrodes and the lead electrodes which are formed inside and on the front and back faces of the piezoelectric element.

6. A manufacturing method for manufacturing an acceleration sensor, comprising the steps of:

preparing $4n + 2$ planar green sheets made of piezoelectric ceramic, where n is an integer greater than or equal to 1;

applying a conductive paste on surfaces of at least three of the green sheets at positions corresponding to a center portion and both end portions of individual piezoelectric elements in the longitudinal direction, whereby segmented electrodes are formed for a plurality of piezoelectric elements;

applying a conductive paste on surfaces of at least two of the other green sheets so

that the conductive paste is led to positions corresponding to ends of each piezoelectric element in the longitudinal direction, whereby lead electrodes are formed for the plurality of piezoelectric elements;

stacking the green sheets so that the segmented electrodes and the lead electrodes are alternately arranged and so that the electrode in the middle in the thickness direction is the segmented electrode;

firing the green sheets to produce a piezoelectric ceramic fired compact which includes a plurality of piezoelectric layers and simultaneously baking the conductive paste;

forming lead electrodes on the front and back faces of the piezoelectric ceramic fired compact, the lead electrodes being led to positions corresponding to the ends of each piezoelectric element in the longitudinal direction;

applying a DC electric field in between the segmented electrodes and the lead electrodes to polarize the piezoelectric ceramic fired compact in the thickness direction so that, when an acceleration is applied, charge having the same polarity is extracted from the lead electrodes in the piezoelectric layers on both sides of the lead electrodes and so that the center portion and both end portions of each piezoelectric layer are polarized in opposite directions;

cutting the piezoelectric ceramic fired compact into individual piezoelectric elements; and

forming external electrodes on both end faces of the cut piezoelectric element and connecting the external electrodes and the lead electrodes which are formed inside and on the front and back faces of the piezoelectric element.

7. A manufacturing method for manufacturing an acceleration sensor, comprising the steps of:

preparing $4n + 1$ planar green sheets made of piezoelectric ceramic, where n is an integer greater than or equal to 1;

applying a conductive paste on surfaces of at least two of the green sheets at positions corresponding to a center portion and both end portions of individual piezoelectric elements in the longitudinal direction, whereby segmented electrodes are formed for a plurality of piezoelectric elements;

applying a conductive paste on surfaces of at least two of the other green sheets so that the conductive paste is led to positions corresponding to ends of each piezoelectric element in the longitudinal direction, whereby lead electrodes are formed for the plurality of piezoelectric elements;

stacking the green sheets so that the electrodes arranged on both sides of the piezoelectric layer in the middle in the thickness direction are the segmented electrodes

and so that the segmented electrodes and the lead electrodes are alternately arranged in the other piezoelectric layers;

firing the green sheets to produce a piezoelectric ceramic fired compact which includes a plurality of piezoelectric layers and simultaneously baking the conductive paste;

forming polarization electrodes on the front and back faces of the piezoelectric ceramic fired compact, the polarization electrodes being segmented into portions according to the positions corresponding to the center portion and both end portions of each piezoelectric element;

applying a DC electric field to the polarization electrodes and in between the segmented electrodes and the lead electrodes to polarize the piezoelectric ceramic fired compact in the thickness direction so that, when an acceleration is applied, charge having the same polarity is extracted from the lead electrodes in the piezoelectric layers on both sides of the lead electrodes and so that the center portion and both end portions of each piezoelectric layer are polarized in opposite directions;

interconnecting the portions of the polarization electrodes or forming continuous electrodes after removing the polarization electrodes, whereby lead electrodes leading to the ends of the piezoelectric element in the longitudinal direction are formed on the front and back faces of the piezoelectric element,

cutting the piezoelectric ceramic fired compact into individual piezoelectric elements; and

forming external electrodes on both end faces of the cut piezoelectric element and connecting the external electrodes and the lead electrodes which are formed inside and on the front and back faces of the piezoelectric element.

8. A manufacturing method for manufacturing an acceleration sensor, comprising the steps of:

preparing $4n + 3$ planar green sheets made of piezoelectric ceramic, where n is an integer greater than or equal to 1;

applying a conductive paste on surfaces of at least four of the green sheets at positions corresponding to a center portion and both end portions of individual piezoelectric elements in the longitudinal direction, whereby segmented electrodes are formed for a plurality of piezoelectric elements;

applying a conductive paste on surfaces of at least two of the other green sheets so that the conductive paste is led to positions corresponding to ends of each piezoelectric element in the longitudinal direction, whereby lead electrodes are formed for the plurality of piezoelectric elements;

stacking the green sheets so that the electrodes arranged on both sides of the

piezoelectric layer in the middle in the thickness direction are the segmented electrodes and so that the segmented electrodes and the lead electrodes are alternately arranged in the other piezoelectric layers;

firing the green sheets to produce a piezoelectric ceramic fired compact which includes a plurality of piezoelectric layers and simultaneously baking the conductive paste;

forming lead electrodes on the front and back faces of the piezoelectric ceramic fired compact, the lead electrodes being led to positions corresponding to the ends of each piezoelectric element in the longitudinal direction;

applying a DC electric field in between the segmented electrodes and the lead electrodes to polarize the piezoelectric ceramic fired compact in the thickness direction so that, when an acceleration is applied, charge having the same polarity is extracted from the lead electrodes in the piezoelectric layers on both sides of the lead electrodes and so that the center portion and both end portions of each piezoelectric layer are polarized in opposite directions;

cutting the piezoelectric ceramic fired compact into individual piezoelectric elements; and

forming external electrodes on both end faces of the cut piezoelectric element and connecting the external electrodes and the lead electrodes which are formed inside and on the front and back faces of the piezoelectric element.